THE RADIUS OF REDUCTION

"Using transportation to assess optimal value chain configuration for minimal environmental impact"

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The Radius of Reduction

- Radius of Reduction (RR) defined as:
  - *How far a feedstock can be transported from operation A to a more efficient operation B without the transport impact outweighing the benefit*

A four level assessment

- RR can be derived for any metric
- Here demonstrated on:

1. **Energy reduction**
   - processing efficiency
2. **Energy emissions reduction**
   - processing specific emissions
3. **Energy impact reduction**
   - water usage
4. **Cost reduction**
   - Carbon tax avoidance

Overall energy balance

$$E_{Total} = D \times EF_{trans} + EF \times E$$

- Where:
- E_{Total} = Total emissions (kg CO_2 / t input mineral)
- D = distance transported (km)
- EF_{trans} = Emissions factor for transport (kg CO_2 / t km)
- EF = Emissions factor for energy usage (kg CO_2 / GJ)
- E = Energy usage (GJ / t)

Rearranging the energy balance

- Distance is equated to difference in emissions or energy

$$\frac{E_{Total} - EF \times E}{EF_{trans}} = D$$

- RR is determined from the difference between two operations:

$$RR = \frac{(EF \times E)_A - (EF \times E)_B}{EF_{trans}}$$

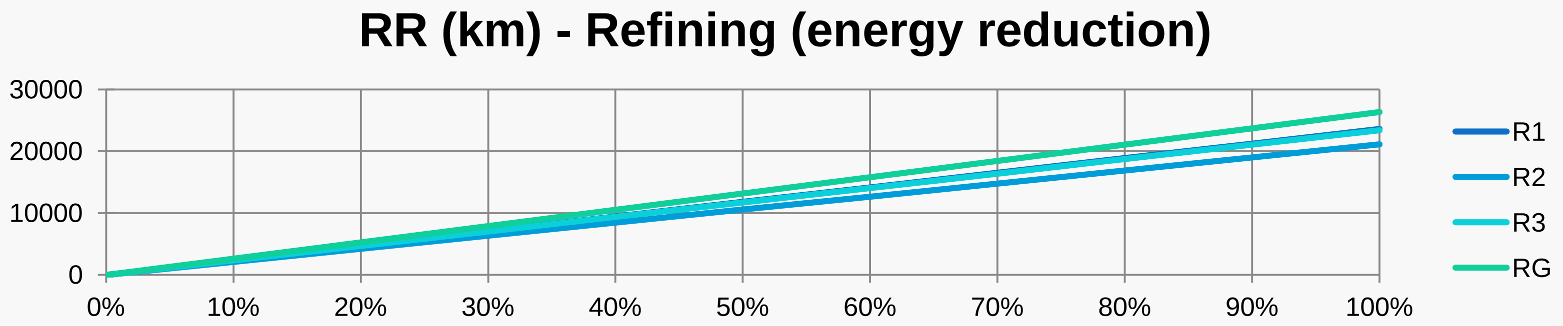
Case study: Aluminium Value Chain

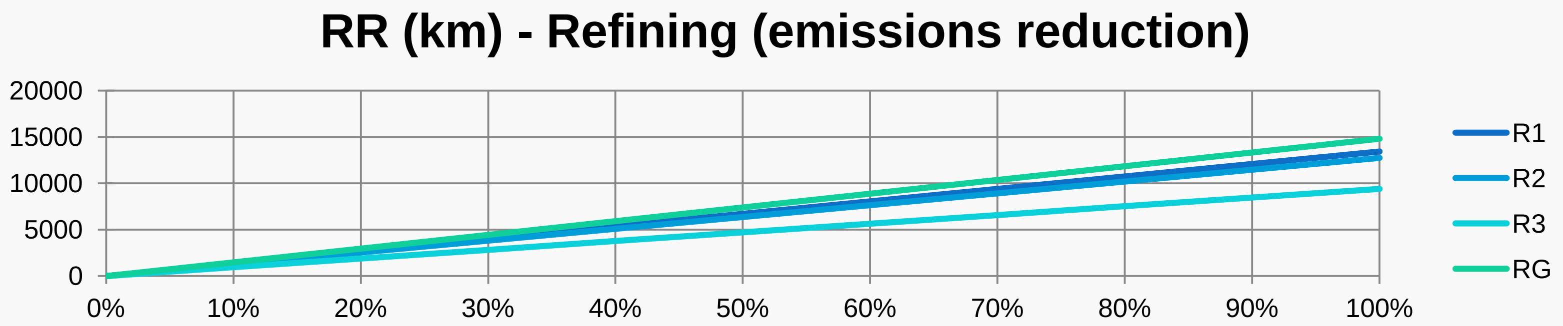
- 4 alternative Bauxite mines
- 4 alternative Alumina refineries
- 4 alternative Aluminium smelters
- Compared across 4 metrics
- Examine the potential of alternative combinations to reduce environmental impact

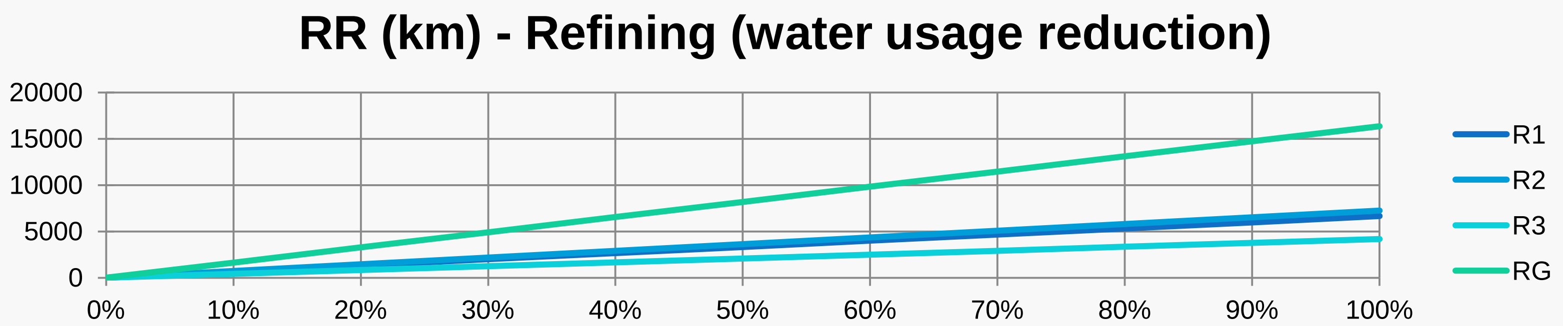
Typical results: Inter-refinery only

- Following graphs indicate RR from each refinery to another theoretical refinery obtaining from 0% to 100% improvement in specific environmental impact.

Typical results: Inter-refinery only



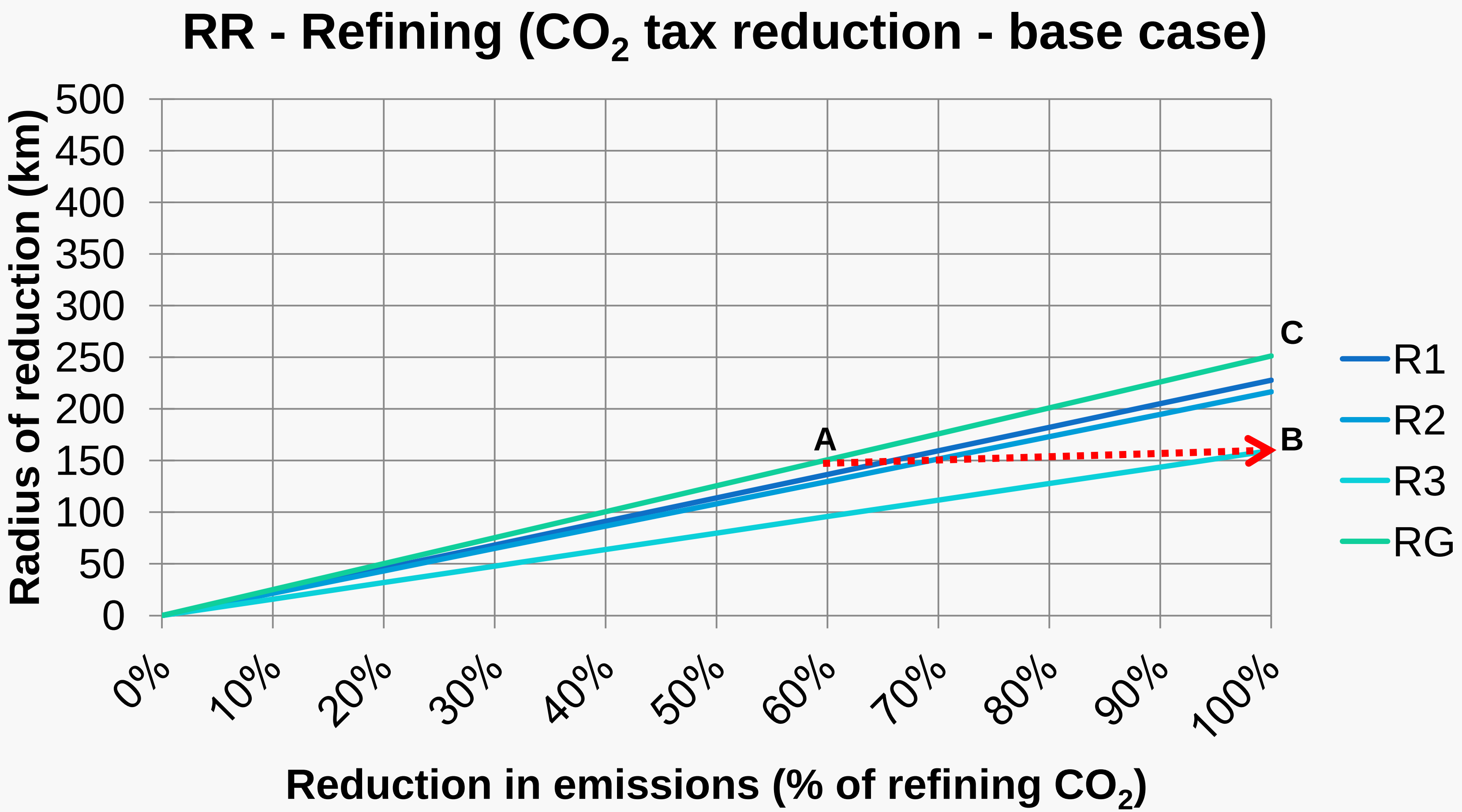




Typical results: Carbon tax

- Can also read from the graph:
- How much distance between two specific refineries is allowable for a given reduction in emissions (or Carbon tax here)?
  - emissions reduction between RG and R3 is (100%-60% = 40%) of RG initial emissions (*difference between x-values at A and C*)
  - Distance allowable between the refineries is (250km – 150km = 100 km) (*difference between y-values at C and B*)
- Uppermost line is the higher emitter

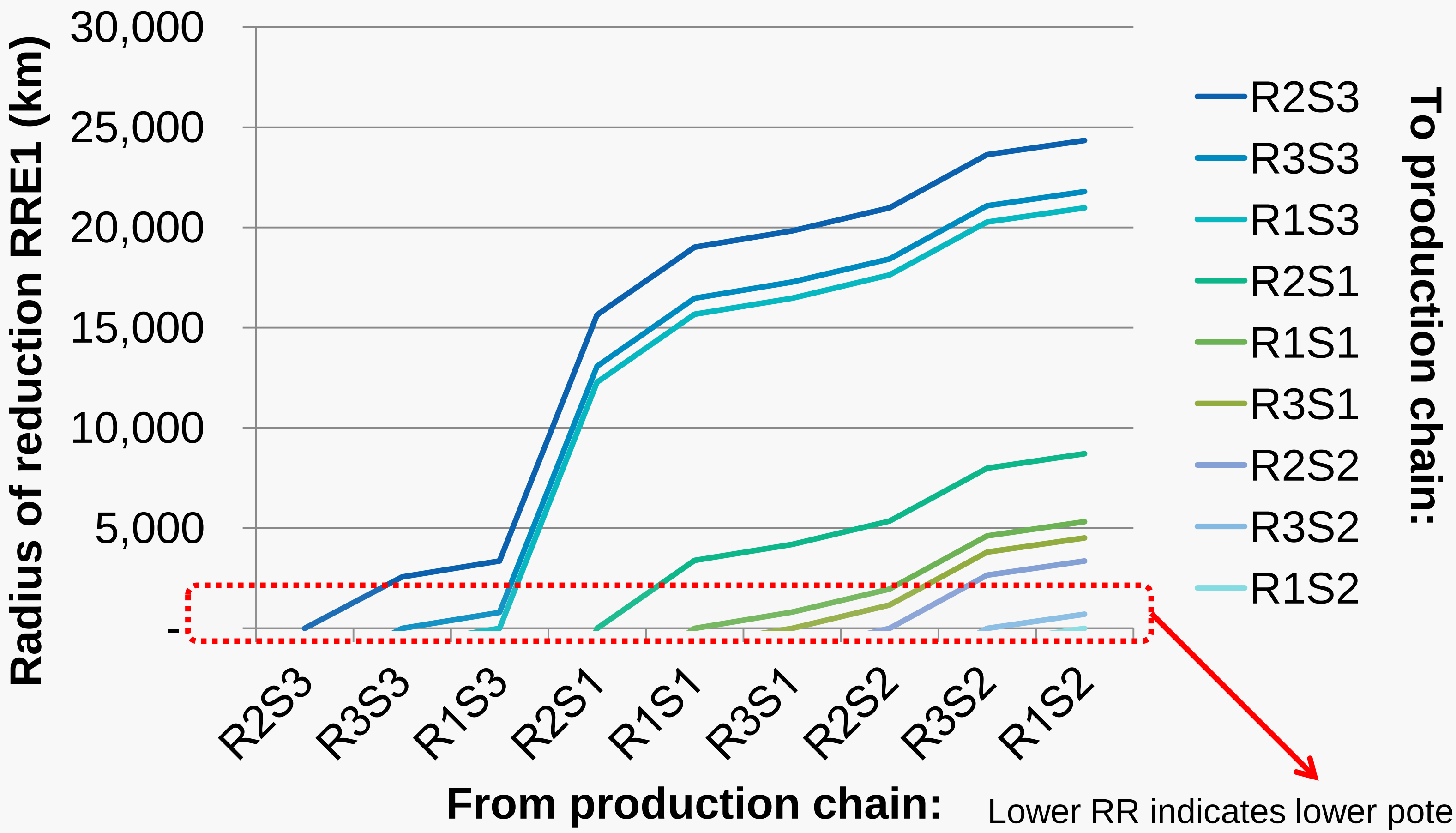
Typical results: Carbon tax



Typical value chain results

- Value chains can be compared as well as single operations in the value chain

Typical value chain results: Energy



Lower RR indicates lower potential for benefit – i.e feedstock can only be transported a small distance

Conclusions

- “radius of reduction” methodology is demonstrated
- can be a useful tool for supply chain planning, purchasing or sales strategy
- ability to reduce energy and emissions are shown to be highest
- water usage and costs associated with a carbon tax are less avoidable through relocation.